

August 13, 2019

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VIA ECFS

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: *Misuse of Internet Protocol (IP) Captioned Telephone Service*, CG Docket No. 13-24,
Telecommunications Relay Services and Speech-to-Speech Services for Individuals with
Hearing and Speech Disabilities, CG Docket No. 03-123

Dear Ms. Dortch:

On Friday, August 9, 2019, Scott Wood, CEO, and Cindy Williams, General Counsel of Sorenson Communications, Inc. and CaptionCall, LLC (collectively, “CaptionCall”); Bryan Cunningham, Polaris Consulting, LLC, consultant to CaptionCall; and the undersigned, met with Commissioner O’Rielly and Arielle Roth, Wireline Legal Advisor to Commissioner O’Rielly, to discuss the pending reforms to set a permanent rate methodology to IP CTS.¹ In the meeting, we discussed the Reverse Auction Proposal for Setting IP CTS rates prepared by Professor Andrzej Skrzypacz and highlighted the benefits of setting rates via an auction.²

Please contact me if you have any questions or require any additional information.

Sincerely,

/s/ Rebekah P. Goodheart
Rebekah P. Goodheart
Counsel CaptionCall, LLC

Attachment

¹ See *In re Misuse of Internet Protocol (IP) Captioned Telephone Service*, Report and Order, Declaratory Ruling, Further Notice of Proposed Rulemaking, and Notice of Inquiry, 33 FCC Rcd 5800 (2018).

² See *Comments of CaptionCall, LLC*, CG Docket Nos. 13-24, 03-123, at Appendix D (Sept. 17, 2018).

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cc: Commissioner O'Rielly
Arielle Roth

REVERSE AUCTION PROPOSAL FOR SETTING IP CTS RATES

Professor Andrzej Skrzypacz
Prepared for CaptionCall, LLC
September 17, 2018

I. Executive Summary

- This proposal describes a reverse auction design that the Federal Communications Commission (“FCC”) could use to set an IP CTS rate competitively.
- This design provides incentives for IP CTS providers participating in the auction (“participants”) to submit low bids. It does so by rewarding winning bidders (low bidders) with preferential access to new customers, and by threatening losing bidders (higher bidders) with no – or lower – compensation from the TRS Fund for minutes used by new customers until the next auction cycle.
- The auction proposed is a multi-round descending clock auction with a uniform rate offered to all winning bidders. At least two winners are guaranteed per auction cycle, and more are possible.
- The proposal envisions that the auction will be conducted annually. Although the Commission could opt for a different interval, an interval of less than one year is not recommended.
- The auction starts with a specified rate (the reserve price). As long as two or more bidders place bids at that price, the rate decreases. Participants are not allowed to see which bidders or how many bidders remain. When only one bidder remains, the auction stops. The winning rate is the last price at which at least two bidders were still active.
- All bidders who were still active at prices within x% (*e.g.*, 5%) of the winning rate become winning bidders. Bidders who dropped out at higher prices become losing bidders. In addition, new entrants and small providers that do not participate in the auction may be treated as winning bidders so long as they satisfy applicable quality standards.

- To protect existing customers, all providers (including winning and losing bidders) may continue offering service to their current IP CTS customers at the winning rate. Losing bidders may not add new customers (or at least may not request TRS Fund reimbursement for any new users they add) during the auction cycle. I also discuss alternative, more lenient treatments of losing bidders and the tradeoffs involved.
- The proposed design facilitates new entrants, including those trying new technologies, by allowing them to start offering service at the winning rate at any time in between auctions (subject to certain eligibility criteria).
- I discuss necessary safeguards that the FCC must include in the auction design to assure the stability of the market and the Fund. Among other things, I propose that the new rate should be phased in gradually over time, in four equal quarterly increments. A phase-in approach will provide some measure of stability for both providers and the Fund, and will reduce the risk of losing bidders exiting the market.

II. Introduction and Objectives

CaptionCall, LLC asked me to design a reverse auction that could be used to set IP CTS rates. In designing this proposal, I have followed the following objectives and principles:

- **Economic Incentives for Bidding:** The auction must create economic incentives by rewarding low bidders relative to high bidders.
- **Preserve Quality of Service:** The process must ensure high quality of service. This objective can be accomplished by imposing eligibility criteria so that only service providers that provide quality service would be qualified to participate in the auction.
- **Preserve Consumer Choice and Minimize Transaction Costs for Existing Customers:** To the greatest extent possible, the process should preserve consumer choice, and existing customers should be able to continue using their existing equipment and provider if they so choose. The proposal accomplishes this goal in two ways. First, all providers may continue to serve

their current customers as long as they are willing to be compensated at the competitively-set rate. Second, the design guarantees that at least two current providers (and potentially more) will win the right to add new customers.

- **Stability of Business:** To the greatest extent possible, the auction should promote stability of business plans for existing providers. In particular, IP CTS rates should not fluctuate too quickly (*i.e.*, the rates for existing users should not change drastically in a short time horizon).
- **Stability of the TRS Fund:** Although the auction should allow rates to increase if costs go up, to protect the stability of the Fund, the FCC should be able to put a cap on the reserve price that guarantees that any rate increases are limited.
- **The Possibility of Entry:** The auction-supported IP CTS rate-setting process should not foreclose new providers from entering the market. In particular, new entrants should be permitted to begin offering service between auctions at the current auction rate, so that they have the option to begin seeking reimbursement at the market price without participating in the auction. These protections should apply to new entrants, so long as they can meet minimum quality standards.
- **Administrative Costs:** The design should seek to minimize organizational and administrative burdens for both the FCC and IP CTS service providers.
- **Uniform Price:** To the extent possible, providers offering the same service should be reimbursed at the same rate.

No auction design can perfectly satisfy all of these principles at the same time. For example, the provision of economic incentives to bid aggressively is intrinsically inconsistent with providing full business security to existing providers. The auction design I propose tries to strike a balance among these different objectives, but several parameters could be modified depending on the FCC's objectives and any industry changes that might occur between now and the auction. For example, it may be appropriate to adjust some of these parameters to reflect the most current information.

III. Auction Design Proposal: Reverse Auction for the Rights to Add New Users

Because IP CTS continues to attract many new users, an auction design that offers low bidders preferential access to new users would create a substantial economic incentive to bid aggressively. Here, preferential access would mean that winning bidders would be allowed to add new customers and receive compensation from the TRS Fund for these customers' IP CTS minutes, while the losing bidders would not. Losing bidders could remain in the IP CTS market by continuing to providing service to their existing customers at the auction-determined rate and attempting to win in the next auction cycle.¹

The proposed auction process and preferential access afforded to winning bidders are described in further detail below.

A. Auction Mechanics: Auction Process, Rate and Winner Determination, and Eligibility Criteria

- **Auction Process:** Auction-eligible service providers may participate in a descending clock (reverse) auction that sets the per-minute reimbursement rate for IP CTS until the next auction cycle.²
 - The auction starts at the reserve price set by the FCC (discussed below) and progresses in a series of rounds.
 - At the beginning of each round, the FCC declares a new opening-round rate and asks all still-active bidders if they are willing to provide service at that rate. Those who bid 'yes' remain active and may participate in the next round. Those who bid 'no' become inactive and drop out of the auction.
 - If there are two or more active bidders, the FCC reduces the opening-round rate by a small bid increment (for example, 2 cents or 1%, whichever is lower) and the auction continues to the next round.

¹ I discuss other alternative forms of preferential access below.

² See below for a discussion of potential alternative treatment of small providers or new entrants.

- When fewer than two active bidders remain at the end of a round, the auction ends. The winning rate is the previous-round rate. (If the auction ends in the first round, the winning rate is the reserve price.)
- Between rounds, the auction reporting system informs bidders only about the current bid rate and whether or not the auction is still active. Information about the number of other bidders still active or the identity of those bidders would not be available.
- **Rate and Winner Determination:**
 - As stated above, the **winning rate** will be equal to the rate in the round prior to the round in which the auction closes.
 - For example, in round k , the rate is \$1.75, so in round $k+1$, the rate becomes \$1.73. There are two active bidders at the end of round k , but one of them becomes inactive in round $k+1$. Then the winning rate is \$1.75.
 - All bidders active in the round prior to the closing round are automatically winning bidders (by definition, there will be at least two).
 - Any other bidders who were still active at the end of any round when the rate was within $x\%$ (e.g., 3-8%) of the winning rate also become winning bidders.
 - Continuing the above example, with the \$1.75 winning rate, if $x\%$ is chosen to be 5%, then any bidder active at the end of the round with rate \$1.84 or less ($\approx \1.75×1.05) is also a winning bidder. These winning providers, like the other winning bidders, may add new subscribers and be compensated at the winning rate of \$1.75.
 - Bidders who became inactive at the end of a round in which the rate was more than $x\%$ different from the winning rate are losing bidders.
- **Eligibility Criteria:** Only service providers that have established their ability to offer quality service to a substantial fraction of the market are eligible to bid in the auction. (As explained below, small providers and new entrants

may be allowed to offer service at the winning rate without participating in the auction.)

B. Preferential Access for Winning Bidders (Allowable Reimbursements and Rates for Winning and Losing Bidders)

For the duration of the period for which the auction sets rates, the winning bidders can grow their business without any constraints (other than standard regulatory requirements – for example, with respect to eligibility). They can offer service to new users and be reimbursed by the FCC at the winning rate.

Losing bidders are not allowed to add new customers; or, if they do add new customers, losing bidders may not receive reimbursement from the FCC for the IP CTS minutes provided to those new customers for the duration of the period for which the auction sets rates.³

All providers (auction winners and losers) can continue serving customers who were using their services before the auction at the **winning rate**. (I discuss below a gliding rate approach so that the rate adjusts gradually over time at a rate no higher than 2.5% a quarter.)

Alternative conditions for **smaller providers and new entrants** are discussed below.

C. Further Considerations in Designing the Auction

1. Reserve Prices

To assure that the auction does not result in unexpected cost increases for the TRS Fund, the FCC may impose a reserve price (rate) that is the highest rate it is willing to pay. The descending-price auction would start at that price.

Note that competition among service providers can drive rates temporarily and inefficiently below costs, so that the reserve price should not automatically be set below the prior year's rate. This can happen, for example, if a service provider miscalculates its

³ See discussion below for a possible relaxation of that constraint.

efficiencies of scale and how much it will be able to grow its market share if it wins the auction. If the reserve price is kept inefficiently low, it can result in providers leaving the market, which in turn would create service interruptions. It is therefore important that the process can self-correct in the next auction cycle.

The auction is designed so that competition among bidders results in fair rates reflecting true costs. The reserve prices should be used solely as a safety mechanism, not to artificially constrain the outcome of the auction.

2. Assuring the Stability of Rates – Phasing-in New Rates

In order to provide stability for both the TRS Fund and for service providers, I propose that the new rate should be phased in gradually over time, in four equal quarterly increments.

For example, if the winning rate decreases by 12 cents/minute, a gradual phase-in would be that it would decrease by 3 cents/minute at the beginning of each quarter over four quarters. Similarly, if the rate increases, the increase would be phased-in over four quarters. For example, if the winning rate increases by 8 cents/minute, the rate at which the FCC reimburses providers would be increased by 2 cents/minute at the beginning of each quarter over four quarters.

Such a gradual adjustment approach would provide some insurance to existing providers and to the Fund. It would reduce the risk of losing bidders being driven out of business as the result of one auction with extreme results. They would have some time buffer to reduce costs to remain competitive.⁴

3. Safeguards

Relying on a reverse auction to set rates introduces some degree of uncertainty into the rate-setting process. First, rates may change year-to-year in response to changes in cost

⁴ If the winning rate differs from the previous-auction winning rate by more than 10%, the phase-in period would be extended and any single quarter adjustment would be capped at 2.5%. To reduce the administrative burden of reporting which customers are reimbursed at which rate, the rate for new customers and for existing customers should be phased in using the same approach.

structures. Second, losing bidders may find themselves shut out of the market for new subscribers. Third, the costs to the TRS Fund may fluctuate unexpectedly.

To balance these issues, I recommend implementing the following safeguards:

- Rates should not change in either direction by more than 2.5% a quarter.
- Auctions should take place once a year, or less frequently (for example, every 18 or 24 months). These intervals will allow losing bidders time to reduce their costs and submit more competitive bids in the next auction. (Auctions should not be held more frequently than annually because incentives to bid aggressively decline when auction cycles are more closely spaced; uncertainty of outcomes could be even more significant; and the administrative and practical burdens on both the Commission and bidders would increase).
- Bidders must be pre-qualified to participate in the auction, by showing credible capability and capacity of providing quality service. They should be providing service at some minimum scale, *e.g.*, 2% of the market. They should also demonstrably satisfy a minimum quality standard. Finally, to avoid costly mistakes and disruption of service, in case a provider has less than 5% of the existing subscribers, it should be asked to demonstrate that their bids are not below their costs.⁵
- The FCC should retain the right to cancel the auction if the winning bids and the winning rate would jeopardize the continued provision of the service (for

⁵ While unrealistically-low rates may, at first, seem beneficial to the Fund, they may not result in any long term benefits to the FCC or to IP CTS users. *See, e.g.*, Letter from Scott R. Freiermuth, Counsel for Sprint Corp., to Marlene H. Dortch, Secretary, Federal Communications Commission, CG Docket Nos. 13-24, 13-123 (June 1, 2018) (discussing collapse of IP Relay market due to providers' exiting market after rate decrease); *see generally In re Telecommunications Relay Services and Speech-to-Speech Services for Individuals with Hearing and Speech Disabilities*, Order, 28 FCC Rcd 9219, 9221-245 ¶¶ 10-20 (CGB 2013); *In re Telecommunications Relay Services and Speech-to-Speech Services for Individuals with Hearing and Speech Disabilities*, Order, 29 FCC Rcd 16,273 (CGB 2014). New service providers that bid unrealistically low could later decide not to offer any service. That may result in service interruptions, lack of new service options, or both. A particularly dangerous scenario would be if two new entrants were to submit unrealistically low bids with no intention to offer service, but instead intending to disrupt the market. For example, new entrants may hope to unfairly reduce competition by offering vastly inferior competing service and disrupting the IP CTS market.

example if the winning rate is unsustainably low) or the sustainability of the Fund (or for any other unforeseen reason).

4. Necessary Data Collection

The reverse auction would require all providers to submit a list of subscriber phone numbers on an annual basis (or each auction cycle). For privacy reasons, these lists could be submitted without disclosing actual names or addresses. All providers would be required to submit this data before the auction to enable the FCC to determine the set of reimbursable minutes for the losing bidders.

5. Information Reporting during the Auction

The auction system would keep confidential the number of active bidders that remain in each round. Were information about other auction participants available, it would create a high risk that the second-lowest bidder would strategically drop out as soon as it learns that only two bidders remain. That, in turn, would provide little incentive for the third-lowest bidder to bid aggressively (because that bidder would reasonably expect that the auction will stop as soon as it becomes inactive). Not knowing how many other bidders are still active and how low the rate may go, a bidder will face a severe risk of being shut out from the market for new customers if it drops out too soon, at a bid price significantly above its per-minute costs.

After the auction ends the winning rate and the set of winning bidders would become public. All other bid data should remain private (not to affect bidding in the next auction).

6. Alternative Treatment of Losing Bidders

The auction I describe above is based on offering the winning bidders significant preferential access to new users: Losing bidders are not allowed to add any new subscribers (or, more precisely, to be reimbursed for any minutes provided to new subscribers) during the auction cycle.

While the risk of being shut out should create powerful incentives for aggressive bidding, it could also produce high costs for losing bidders if it required them to shut down their marketing and outreach until the next auction cycle.

An alternative solution would be to allow the losing bidders to continue adding new users but only at a lower rate than the winning bidders (for example, the FCC could compensate losing bidders at 80% of the winning rate). Although that reduced rate may be below losing providers' average costs, it may nonetheless be higher than the marginal cost if one takes into account the costs of closing the outreach organization for a year and later having to re-build it.

A provision of that kind would provide an additional safeguard for the IP CTS providers. Even if they are not winning bidders in the auction, the lower rate would apply only to new customers; and existing customers would still be reimbursed at the winning rate. As an additional safeguard, the FCC could consider imposing the lower rate for only one year from the time the new customer starts using the service (even if the auction cycle is longer than a year).⁶

The tradeoff in choosing the level of preferential access for the winning bidders (and hence treating the losing bidders more or less leniently) is that more lenient treatment of losing bidders results in weaker incentives for participants to bid aggressively in the auction. On the other hand, a strict rule against losing bidders adding new subscribers may create an unnecessary administrative burden on both service providers and the FCC and lead to inefficient management of providers' outreach and marketing operations.

7. Small Providers and New Entrants

Small providers (for example, those with less than 2% of prior-year minutes) and new entrants may lack the capacity to serve a large enough fraction of the flow of new

⁶ A different solution would be to allow losing bidders to add some new customers at the winning rate, but with a binding constraint on the number related to the past-year number of added subscribers and the expected overall growth of subscribers. That solution would have similar tradeoffs as the lower-than-market rate solution.

customers to participate in the auction. These providers may also lack the expertise to participate in the auction or may find such participation too costly.

In order to protect the opportunities for market entry, the FCC may offer such new entrants and small providers the option of being treated as a winning bidder without participating in the auction. This accommodation would promote new entry and experimentation in the provision of new services. This option may be attractive to providers that find it hard to estimate the costs of providing the service at scale and may prefer to offer service at the “market rate.” Moreover, such a provision would also allow new entry between auctions (*i.e.*, even if the auctions set prices July-June, this would allow new entrants to enter in January, for example). Finally, the FCC may choose to offer this provision to small providers only for a limited time.

To the extent that the FCC wants to further accommodate new entrants and small providers, it could extend this option further. For instance, the option of being treated as a winning bidder without participating in the auction could be available to new entrants for a set amount of time (for example, for two years per provider, even if the provider grows above the 2% threshold in that time).

The FCC must maintain safeguards to encourage responsible entry of providers that can deliver service above the minimum acceptable quality. In particular, the pre-qualification criteria for existing service providers seeking compensation from the Fund should apply equally to providers that opt to be treated as winning bidders without participating in the auction.

8. Frequency of Auctions

The above proposal assumes that the FCC will conduct auctions annually to determine rates and identify winning and losing bidders (as well as the preferential access winning bidders receive) for the next twelve months. In the alternative, the FCC could hold auctions less frequently (for example, at 18- or 24-month intervals). On the one hand, more frequent auctions would allow losing bidders to adjust their business and “get back in the game” sooner. On the other hand, less frequent auctions would reduce the administrative burden for the bidders and the FCC, and afford losing bidders time to

make meaningful changes. Again, an auction period of less than one year is not recommended. In addition to increasing administrative burdens, more frequent auctions could negatively impact the stability of providers' business and the predictability of Fund compensation.

IV. Conclusions

A reverse auction provides a workable method to determine the market-based IP CTS rates. Because IP CTS is currently being delivered by multiple providers, a well-structured auction can provide incentives for aggressive bidding and at the same time maintain sufficient continuity of business and consumer choice. An auction of this kind would offer stronger incentives for process and product innovation than would methods based on submitted costs. And, in the long run, an auction-based process is likely to result in better service at lower cost to the Fund and the public than would a methodology based on submitted costs.

Andrzej (Andy) Skrzypacz

CV September 2018

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Education

Ph.D. Economics, University of Rochester, 2000.
M.A. Economics, University of Rochester, 2000.
M.A. (magisterium) Economics, Warsaw School of Economics, Warsaw, Poland, 1997.
B.S. (licencjat) Economics, Warsaw School of Economics, Warsaw, Poland, 1995.

Employment:

Stanford Graduate School of Business 2000-present:
 Theodore J. Kreps Professor of Economics, 2010- present.
 Professor of Economics, 2009-2010.
 Associate Professor of Economics, 2004-2009 (with tenure since 2007).
 Assistant Professor of Economics, 2000-2004.
Stanford University:
 Professor, by courtesy, Department of Economics, Stanford, 2012- present
 Co-Director, Executive Program in Strategy and Organization 2014-present
Yahoo! Research, 2011 – 2012.
 Academic Visitor

Main Professional Service

Co-Editor of the American Economic Review 2011-2014
Associate Editor for the American Economic Review: Insights 2017 -
Associate Editor for the RAND Journal of Economics. 2008-
Associate Editor for Theoretical Economics. 2009-2011
Associate Editor for the American Economic Review. 2006 -2011

Research

Published and Accepted Papers

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16. William Fuchs and Andrzej Skrzypacz (2013) "Bridging the Gap: Bargaining with Interdependent Values" *Journal of Economic Theory*, 148(3), pp.1226–1236.
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32. Felipe Varas, Ivan Marinovic and Andrzej Skrzypacz and (2017) "Random Inspections and Annual Reviews: Optimal Dynamic Monitoring."
33. Dmitry Orlov, Andrzej Skrzypacz and Pavel Zryumov (2018) "Persuading the Regulator To Wait." Stanford GSB Working Paper No. 3406. (R&R in Journal of Political Economy)
34. Peter DeMarzo, Ilan Kremer and Andrzej Skrzypacz (2017) "Test Design and Minimum Standards." (R&R in American Economic Review)
35. Dmitry Orlov, Pavel Zryumov and Andrzej Skrzypacz (2017) "Design of Macro-Prudential Stress Tests."
36. William Fuchs and Andrzej Skrzypacz (2017) "Timing Design in the Market for Lemons." (R&R in Review of Economic Dynamics)

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37. April Franco, Matthew Mitchell, and Andrzej Skrzypacz (2017) "An Economic Theory of Dynamic Capabilities." In "Oxford Handbook on Dynamic Capabilities" Editors: Sunyoung Lee and David J. Teece.
38. Johannes Hörner and Andrzej Skrzypacz (2017) "Learning, Experimentation, and Information Design." In B. Honoré, A. Pakes, M. Piazzesi, & L. Samuelson (Eds.), *Advances in Economics and Econometrics: Eleventh World Congress (Econometric Society Monographs*, pp. 63-98). Cambridge: Cambridge University Press.

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39. Ilan Kremer and Andrzej Skrzypacz (2006) "Information Aggregation and the Information Content of Order Statistics."
40. Jerzy Konieczny and Andrzej Skrzypacz (2006) "Search, Costly Price Adjustment and the Frequency of Price Changes – Theory and Evidence."
41. Matthew Mitchell and Andrzej Skrzypacz (2006) "Market Structure and the Direction of Technological Change."
42. Ilan Kremer and Andrzej Skrzypacz (2004). "Auction Selection by an Informed Seller."
43. Andrzej Skrzypacz (2004) "Bargaining under Asymmetric Information and the Hold-up Problem."

Main Non-Refereed Articles, Policy Briefs and Opinion Pieces

44. Gregory Rosston and Andrzej Skrzypacz "- Using Auctions and Flexible-Use Licenses to Maximize the Social Benefits from Spectrum." Submitted to the FCC in September 2017 and prepared on behalf of T-Mobile.
45. Susan Athey and Andrzej Skrzypacz (2017). "Yuliy Sannikov: Winner of the 2016 Clark Medal." *Journal of Economic Perspectives*, 31(2): 237-56.
46. Gregory Rosston and Andrzej Skrzypacz "Moving from Broadcast Television to Mobile Broadband: The FCC's 2016 Incentive Auction," SIEPR Policy Brief, January 2016.
47. Gregory Rosston, and Andrzej Skrzypacz "A Dynamic Market Rule for the Broadcast Incentive Auction: Ensuring Spectrum Limits Do Not Reduce Spectrum Clearance." Submitted to the FCC and prepared for T-Mobile.
48. Paul Milgrom, Gregory Rosston, and Andrzej Skrzypacz "Using Procurement Auctions to Allocate Broadband Stimulus Grants." SIEPR Policy Brief, May 2009.
49. "Comments of 71 Concerned Economists: Using Procurement Auctions to Allocate Broadband Stimulus Grants," organized by Paul Milgrom, Gregory Rosston, Andrzej Skrzypacz, and Scott Wallsten, submitted to NTIA April 13 2009.
50. Andrzej Skrzypacz "Economic Analysis of the Provision Of Roaming Services in the Wireless Service Industry," filed Nov. 30, 2009 at the FCC prepared for T-Mobile.

51. Gregory Rosston and Andrzej Skrzypacz “The FCC’s 700 MHz Auction.” SIEPR Policy Brief , December 2007
52. Peter Cramton, Andrzej Skrzypacz and Robert Wilson “The 700 MHz Spectrum Auction: An Opportunity to Protect Competition In a Consolidating Industry,” submitted to the U.S. Department of Justice, Antitrust Division, 13 November 2007 and prepared for Frontline Wireless, LLC .
53. Peter Cramton, Gregory Rosston, Andrzej Skrzypacz and Robert Wilson “Comments on the FCC’s Proposed Competitive Bidding Procedures for Auction 73,” 31 August 2007 and prepared for Frontline Wireless, LLC.
54. Peter Cramton, Andrzej Skrzypacz and Robert Wilson “Revenues in the 700 MHz Spectrum Auction” Working Paper, University of Maryland, 27 June 2007 and prepared for Frontline Wireless, LLC.

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